How Accurate is Land / Ocean Moisture Transport Variability in Reanalyses?

F. R. Robertson, M. G. Bosilovich

Quantifying the global hydrological cycle and its variability across various time scales remains a challenge to the climate community. Direct measurements of evaporation (E), evapotranspiration (ET), and precipitation (P) are not feasible on a global scale, nor is the transport of water vapor over the global oceans and sparsely populated land areas. Expanding satellite data streams have enabled development of various water (and energy) flux products, complementing reanalyses and facilitating observationally constrained modeling. But the evolution of the global observing system has produced additional complications--improvements in satellite sensor resolution and accuracy have resulted in "epochs" of observational quasi-uniformity that can adversely affect reanalysis trends.

In this work we focus on vertically integrated moisture flux convergence (VMFC) variations within the period 1979 - present integrated over global land. We show that VMFC in recent reanalyses (e.g. ERA-I, NASA MERRA, NOAA CFSR and JRA55) suffers from observing system changes, though differently in each product. Land Surface Models (LSMs) forced with observations-based precipitation, radiation and near-surface meteorology share closely the interannual P-ET variations of the reanalyses associated with ENSO events. (VMFC over land and P-ET estimates are equivalent quantities since atmospheric storage changes are small on these scales.) But the long-term LSM trend over the period since 1979 is approximately one-fourth that of the reanalyses. Additional reduced observation reanalyses assimilating only surface pressure and /or specifying sea-surface temperature also have a much smaller trend in P-ET like the LSMs.

We explore the regional manifestation of the reanalysis P-ET / VMFC problems, particularly over land. Both principal component analysis and a simple time series changepoint analysis highlight problems associated with data poor regions such as Equatorial Africa and, for one reanalysis, the Equatorial Andes region. Onset of the availability of passive microwave Special Sensor Microwave Imager (SSMI) moisture data in July 1987 and the transition from the Microwave Sounder Unit (MSU) to an advanced version (AMSU) have significant impacts on VMFC variability. Simple accounting for these errors of leading importance results in modified reanalysis VMFC estimates that agree much better with the LSM results. Regional details of the modified reanalysis VMFC and LSM P-ET are related to changes in Pacific Decadal Variability as manifest in SST changes after the late 1990s.